Agency for Healthcare Research and Quality
Advancing Excellence in Health Care

NATIONAL GUIDELINE CLEARINGHOUSE

General

Guideline Title

ACR Appropriateness Criteria® head trauma.

Bibliographic Source(s)

Shetty VS, Reis MN, Aulino JM, Berger KL, Broder J, Choudhri AF, Karagulle Kendi AT, Kessler MM, Kirsch CF, Luttrull MD, Mechtler LL, Prall JA, Raksin PB, Roth CJ, Sharma A, West OC, Wintermark M, Cornelius RS, Bykowski J, Expert Panel on Neurologic Imaging. ACR Appropriateness CriteriaÂ® head trauma. Reston (VA): American College of Radiology (ACR); 2015. 18 p. [64 references]

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Davis PC, Wippold FJ II, Cornelius RS, Aiken AH, Angtuaco EJ, Berger KL, Broderick DF, Brown DC, Douglas AC, McConnell CT Jr, Mechtler LL, Prall JA, Raksin PB, Roth CJ, Seidenwurm DJ, Smirniotopoulos JG, Waxman AD, Coley BD, Expert Panel on Neurologic Imaging. ACR Appropriateness Criteria® head trauma. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 14 p. [64 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: Head Trauma

Variant 1: Minor or mild acute closed head injury (GCS ≥13), imaging not indicated by NOC or CCHR or NEXUS-II clinical criteria (see Appendix 1 of the original guideline). Initial study.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	2	.	
MRI head without contrast	1		O

Radiologic Procedure	Rating	Comments	RRL*
MRA head and neck without contrast	1		O
MRA head and neck without and with contrast	1		O
CT head without and with contrast	1		
CTA head and neck with contrast	1		
MRI head without and with contrast	1		O
MRI head without contrast with DTI	1		O
CT head with contrast	1		
X-ray skull	1		
FDG-PET/CT head	1		
Arteriography cervicocerebral	1		
Tc-99m HMPAO SPECT head	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Minor or mild acute closed head injury (GCS ≥13), imaging indicated by NOC or CCHR or NEXUS-II clinical criteria (see Appendix 1 of the original guideline document). Initial study.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		
MRI head without contrast	5	This procedure may be appropriate in the outpatient setting, but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
MRA head and neck without contrast	2		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative

Radiologic Procedure	Rating	Comments	RRL*
MRA head and neck without and with contrast	2		O
CTA head and neck with contrast	1		
MRI head without and with contrast	1		O
MRI head without contrast with DTI	1		O
CT head without and with contrast	1		
CT head with contrast	1		
Tc-99m HMPAO SPECT head	1		
FDG-PET/CT head	1		
X-ray skull	1		
Arteriography cervicocerebral	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Moderate or severe acute closed head injury (GCS <13). Initial study.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		
MRI head without contrast	2		O
CTA head and neck with contrast	2		
MRA head and neck without contrast	1		O
MRA head and neck without and with contrast	1		O
CT head without and with contrast	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	1		O
MRI head without contrast with DTI	1		O
X-ray skull	1		
CT head with contrast	1		
FDG-PET/CT head	1		
Arteriography cervicocerebral	1		
Tc-99m HMPAO SPECT head	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: Short-term follow-up imaging of acute traumatic brain injury. No neurologic deterioration.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	5	This procedure can be used in patients with risk factors (see narrative below).	
CTA head and neck with contrast	2		
MRI head without contrast	2		O
MRA head and neck without contrast	2		O
MRA head and neck without and with contrast	2		O
CT head without and with contrast	1		
CT head with contrast	1		

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	1		O
MRI head without contrast with DTI	1		O
X-ray skull	1		
FDG-PET/CT head	1		
Tc-99m HMPAO SPECT head	1		
Arteriography cervicocerebral	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Short-term follow-up imaging of acute traumatic brain injury. Neurologic deterioration, delayed recovery, or persistent unexplained deficits.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		
MRI head without contrast	8	This procedure is complementary if CT does not explain clinical symptoms.	O
CT head without and with contrast	5	This procedure can be used in patients with suspected post-traumatic infection.	
CTA head and neck with contrast	5	See Variant 7 below. This procedure may be appropriate in patients with suspected post-traumatic infarction, but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	
MRI head without and with contrast	5	This procedure may be appropriate in patients with suspected post-traumatic infection, but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
MRA head and neck without contrast	5	See Variant 7 below. This procedure may be appropriate in patients with suspected post-traumatic infarction, but there was disagreement among panel members on the appropriateness rating as defined by	O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Radiologic Procedure	Rating	Comments	RRL*
		the panel's median rating.	
MRA head and neck without and with contrast	5	See Variant 7 below. This procedure may be appropriate in patients with suspected post-traumatic infarction, but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
CT head with contrast	4	This procedure can be used in patients with suspected post-traumatic infection.	
MRI head without contrast with DTI	2		O
X-ray skull	1		
FDG-PET/CT head	1		
Tc-99m HMPAO SPECT head	1		
Arteriography cervicocerebral	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 6: Subacute or chronic traumatic brain injury with new cognitive and/or neurologic deficit(s).

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	9		O
CT head without contrast	7	This procedure is an alternative; it is usually the first-line procedure in rapidly evolving new neurologic deficits or if MRI is contraindicated.	
MRA head and neck without contrast	3		O
MRA head and neck without and with contrast	3		O
FDG-PET/CT head	2		
CTA head and neck with contrast	2		

Radiologic Procedure	Rating	Comments	RRL*
MRI functional (fMRI) head without contrast	2		O
MR spectroscopy head without contrast	2		O
MRI head without and with contrast	1		O
MRI head without contrast with DTI	1		O
CT head without and with contrast	1		
CT head with contrast	1		
X-ray skull	1		
Tc-99m HMPAO SPECT head	1		
Arteriography cervicocerebral	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 7: Suspected intracranial arterial injury.

Radiologic Procedure	Rating	Comments	RRL*
CTA head and neck with contrast	9	This procedure is an alternative; either CTA or MRA can be performed, depending on institutional preference.	
MRA head and neck without and with contrast	9	This procedure is an alternative; either CTA or MRA can be performed, depending on institutional preference.	O
MRI head without contrast	9	This procedure is complementary, in conjunction with MRA.	O
CT head without contrast	9	This procedure is complementary, in conjunction with CTA.	
MRA head and neck without contrast	7	This procedure is an alternative; either CTA or MRA can be performed, depending on institutional preference.	O
Arteriography cervicocerebral	6		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	3		O
CT head without and with contrast	1		
MRI head without contrast with DTI	1		O
CT head with contrast	1		
X-ray skull	1		
Tc-99m HMPAO SPECT head	1		
FDG-PET/CT head	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 8: Suspected intracranial venous injury.

Radiologic Procedure	Rating	Comments	RRL*
CT venography head with contrast	9	This procedure is an alternative; either CTV or MRV can be performed, depending on institutional preference.	
MR venography head without contrast	9	This procedure is an alternative; either CTV or MRV can be performed, depending on institutional preference.	O
MR venography head without and with contrast	9	This procedure is an alternative; either CTV or MRV can be performed, depending on institutional preference.	O
CT head without contrast	7	This procedure is complementary, in conjunction with CTV.	
MRI head without and with contrast	6		O
Arteriography cervicocerebral	6		
MRI head without contrast	5	This procedure is complementary, in conjunction with MRV. This procedure may be appropriate but there	O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Radiologic Procedure	Rating	Comments	RRL*
		was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	
CT head without and with contrast	3		
CT head with contrast	2		
MRI head without contrast with DTI	1		O
X-ray skull	1		
Tc-99m HMPAO SPECT head	1		
FDG-PET/CT head	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 9: Suspected post-traumatic cerebrospinal fluid (CSF) leak.

Radiologic Procedure	Rating	Comments	RRL*
CT maxillofacial without contrast	9	This procedure is an alternative in cases of suspected CSF rhinorrhea.	
CT temporal bone without contrast	9	This procedure is an alternative in cases of suspected CSF otorrhea.	
CT head cisternography with contrast	8	This procedure is complementary if CT maxillofacial or temporal bone is inconclusive.	
In-111 DTPA cisternography	6		
MRI head without contrast	5	This procedure is used for suspected cephalocele.	O
CT head without contrast	3		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	3		O
CT head without and with contrast	1		
CT head with contrast	1		
MRI head without contrast with DTI	1		O
X-ray skull	1		
FDG-PET/CT head	1		
Tc-99m HMPAO SPECT head	1		
Arteriography cervicocerebral	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

Head trauma is a common neurologic condition and is associated with significant long-term morbidity and mortality. Neuroimaging plays a critical role in the management of head trauma, from identifying patients with traumatic brain injury (TBI) and determining which of those injuries require immediate treatment to assisting in patient prognosis. The Glasgow Coma Scale (GCS) score is commonly used to stratify the severity of TBI into mild (GCS score of 13–15), moderate (GCS score of 9–12), and severe (GCS score of 3–8). Head trauma in the pediatric patient is addressed in the National Guideline Clearinghouse (NGC) summary of the ACR Appropriateness Criteria® head trauma—child.

Overview of Imaging Modalities

Computed tomography (CT) and magnetic resonance imaging (MRI) are the most widely available neuroimaging modalities in assessing head trauma. Advanced MRI techniques are discussed further in the section on imaging of subacute and chronic TBI. CT angiography (CTA) and MR angiography (MRA) as well as conventional catheter angiography are addressed in the section on imaging of suspected intracranial arterial injury. CT venography (CTV) and MR venography (MRV) are addressed in the section on imaging of suspected intracranial venous injury. CT cisternography is addressed in the section on imaging of suspected post-traumatic cerebrospinal fluid (CSF) leak.

The advantage of CT in evaluating the head-injured patient is its sensitivity for depicting intracranial mass effect, ventricular size and configuration, bone injuries, and acute intracranial hemorrhage regardless of location (i.e., parenchymal, subarachnoid, subdural, or epidural spaces) in a rapid and efficient manner that is widely available and compatible with other medical and life-support devices. Multiplanar reformats may add value in detecting certain intracranial hemorrhages, especially along bone surfaces that approximate the transverse plane of axial images. CT is also more sensitive than MRI in detecting bony injuries. The use of a dedicated bone algorithm, multiplanar reformats, and 3-D rendering may improve the detection of nondisplaced skull fractures. The limitation of CT is a decreased sensitivity to detect small and predominantly nonhemorrhagic lesions, such as contusion or subtle diffuse axonal injury (DAI), subtle injuries adjacent to bony surfaces, and early cerebral edema, which can be seen in hypoxic-ischemic encephalopathy in patients with moderate or severe acute closed head injury. Potential risks of unnecessary exposure to ionizing radiation warrant judicious patient selection for CT scanning as well as radiation dose management.

MRI (including a blood-sensitive sequence such as T2*) is more sensitive than CT in detecting all stages of intracranial hemorrhage, nonhemorrhagic contusions, injuries in the posterior fossa and brainstem, and DAI. The addition of susceptibility-weighted imaging in MRI for head trauma further increases the sensitivity for detection of microhemorrhages and hemorrhagic axonal injury. Limitations of MRI lie in its longer acquisition time, relatively circumscribed availability, and potential incompatibility with certain medical devices.

The use of intravenous contrast offers no significant advantage in nonvascular neuroimaging for head trauma and is generally not indicated.

Skull radiography has been supplanted by CT in characterizing skull fractures in the setting of acute TBI, though it may be useful in limited circumstances, such as radiopaque foreign bodies.

Discussion of Imaging Modalities by Variant

Variant 1: Minor or Mild Acute Closed Head Injury (GCS ≥13), Imaging Not Indicated by New Orleans Criteria (NOC) or Canadian CT Head Rules (CCHR) or National Emergency X-Ray Utilization Study (NEXUS-II) Clinical Criteria (see Appendix 1 in the original guideline document). Initial Study

Variant 2: Minor or Mild Acute Closed Head Injury (GCS ≥13), Imaging Indicated by NOC or CCHR or NEXUS-II Clinical Criteria (see Appendix 1 in the original guideline document). Initial Study

One of the challenges facing physicians is determining which patients with minor or mild acute closed head injury can safely avoid noncontrast head CT. The NOC, CCHR, and NEXUS-II are clinical guidelines with a high sensitivity for identifying patients with minor or mild acute closed head injury who can safely avoid noncontrast head CT. All guidelines have a trade-off between sensitivity and specificity for the detection of significant findings in head-injured patients. The guidelines proposed by each of these studies are listed in Appendix 1 in the original guideline document.

Although noncontrast head CT is normal in the majority of patients with minor or mild acute closed head injury, it remains the primary modality for detecting clinically relevant brain injuries in this patient population. Though noncontrast head CT has a high negative predictive value in triaging patients, this does not mean that a patient with a negative head CT does not have TBI, and neurologically abnormal patients should be followed closely despite a negative head CT.

MRI is not indicated as the initial imaging modality in the setting of minor or mild acute closed head injury. However, it may have a role in follow-up imaging (see Variants 4 and 5 below).

Variant 3: Moderate or Severe Acute Closed Head Injury (GCS <13). Initial Study

For patients with moderate or severe acute closed head injury, noncontrast CT is the recommended initial imaging study.

MRI is not indicated as the initial imaging modality in the setting of moderate to severe acute closed head injury. However, it may have a role in follow-up imaging (see Variants 4 and 5).

Variant 4: Short-term Follow-up Imaging of Acute Traumatic Brain Injury. No Neurologic Deterioration

Variant 5: Short-term Follow-up Imaging of Acute Traumatic Brain Injury. Neurologic Deterioration, Delayed Recovery, or Persistent Unexplained Deficits

Follow-up noncontrast head CT is the recommended imaging modality in trauma patients with acute neurologic deterioration. The value of repeat noncontrast head CT in patients with a negative initial head CT and a stable neurologic examination is low. The value of repeat noncontrast head CT in patients with an abnormal initial head CT and a stable neurologic examination is also low, unless the patient has subfrontal/temporal intraparenchymal contusions, is anticoagulated, is >65 years of age, or has an intracranial hemorrhage with a volume of >10 mL.

MRI is recommended if the patient has ongoing neurologic findings or progressive neurologic symptoms unexplained by CT in minor or mild acute closed head injury and moderate to severe acute closed head injury. MRI has an increased sensitivity to detect intracranial injuries such as contusions, axonal injury, or extra-axial hemorrhage that may be occult on CT. Contrast-enhanced MRI or CT may be helpful if post-traumatic infection is clinically suspected in patients with risk factors such as skull base fractures. For patients in which post-traumatic infarction is suspected from intracranial arterial injury, please see Variant 7. Although the use of MRI in patients with minor or mild acute closed head injury has not been found to change the management or disposition in the acute setting, the clinical significance of these findings in the nonemergent setting is an area of active research. In patients with moderate to severe acute closed head injury, early MRI (within 4 weeks) has shown DAI, with a negative prognosis seen in subjects with brainstem injury.

Variant 6: Subacute or Chronic Traumatic Brain Injury with New Cognitive and/or Neurologic Deficit(s)

Chronic traumatic encephalopathy has come under increased scrutiny in the last several years and clinically represents a wide spectrum of symptoms, including cognitive impairment, epilepsy, and visual and auditory deficits. The biology of chronic traumatic encephalopathy is an area of active investigation. The purposes of imaging patients with chronic TBI are to improve identification of underlying injuries, to assist in patient prognosis, and to guide in the need for referral to a specialist.

MRI is the principal modality for detecting subacute to chronic TBI, with its increased sensitivity to detect and characterize brain injuries, especially atrophy and microhemorrhages, and is recommended in patients with new, persistent, or increasing neurologic deficits. For example, the number, size, and location of MR abnormalities in subacute head injury have been used to predict the recovery outcome of patients in a posttraumatic vegetative state.

Although MRI is superior to CT in detection of chronic sequelae of TBI such as microhemorrhages, head CT may suffice if the aim of imaging is to show areas of atrophy and often helps in documenting the absence of other structural abnormalities (such as an enlarging subacute to chronic subdural hematoma) that might require active intervention.

Advanced neuroimaging techniques (single-photon emission computed tomography [SPECT], positron emission tomography [PET], perfusion CT and MRI, diffusion tensor imaging [DTI], functional MRI (fMRI), and magnetic resonance spectroscopy [MRS]) may have a role in assessing cognitive and neuropsychological disturbances as well as their evolution following head trauma.

SPECT and PET have been studied in patients with subacute and chronic TBI. SPECT studies have revealed focal areas of hypoperfusion without a correlate on MRI or CT. Similarly, PET studies with fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG) tracer have revealed areas of decreased metabolism more extensive than the abnormalities detected on CT or MRI. Finally, perfusion imaging with CT or MRI has also shown areas of decreased cerebral blood flow after trauma without an anatomic correlate on CT or MRI. There is ongoing investigation as to whether these findings might explain or predict postinjury neuropsychological and cognitive deficits not explained by anatomic abnormalities detected by MRI or CT.

DTI is a technique that acquires and reconstructs MR images with diffusion weighting in at least 6 directions, followed by calculation of the tensor to create a model of diffusion in 3-D space. This allows for exploitation of the inherent directionally dependent diffusion in coherently oriented axonal fibers to image white-matter fiber tracts. This information can be postprocessed and displayed as diffusion anisotropy maps, color-coded fiber orientation maps, or 3-D fiber tracking. This technique has shown changes in the white matter of patients with TBI, though only some of these changes have correlated with clinical outcomes.

fMRI has been studied in the setting of TBI using task-based methods such as work-memory paradigms but may be circumscribed in its ability to identify changes in TBI patients caused by the potential uncoupling of neural activity and cerebral blood flow by the TBI.

MRS, an MRI technique used to form a spectrum of the different brain metabolites in a sampled volume of brain tissue, has also been examined in patients with TBI. A reduction in N-acetylaspartate/creatine ratio and absolute N-acetylaspartate on MRS has been seen in several studies.

Although these advanced imaging techniques are of particular interest in patients with mild TBI when CT and conventional MRI are negative, there is no conclusive evidence supporting their use for diagnosis or prognostication at the individual patient level at this time.

Variant 7: Suspected Intracranial Arterial Injury

Traumatic intracranial arterial injuries such as dissection, occlusion, fistula, and pseudoaneurysm formation are diagnosed in approximately 0.1% of all patients hospitalized for trauma, though the majority of these patients come to attention because of clinical symptoms related to central nervous system ischemia. Screening for traumatic intracranial arterial injury should be considered in patients with neurologic symptoms unexplained by a diagnosed injury and blunt trauma patients with epistaxis from a suspected arterial source. Other risk factors for intracranial arterial injury include GCS ≤8, skull base fracture (particularly those that traverse the carotid canal), DAI, cervical spinal fracture (particularly those from the level of C1 to C3), and LeFort 2 or 3 facial bone fractures. Although conventional catheter angiography is considered the gold standard for detecting intracranial arterial injury, multidetector CTA has been found to have a high sensitivity and specificity for diagnosing vascular injury and is less invasive and more readily available. MRA also has a high sensitivity and specificity but may be less readily available. Similarly, conventional catheter angiography is generally used in patients with an inconclusive CTA or in patients undergoing endovascular intervention. Based on the current evidence, CTA or MRA (depending on the institutional preference and availability) is considered first line in imaging patients with suspected intracranial arterial injury.

Variant 8: Suspected Intracranial Venous Injury

Traumatic dural sinus thrombosis is most commonly seen in patients with skull fractures that extend to a dural venous sinus or the jugular foramen.

In a recent study, CTV depicted thrombosis in 40% of patients with skull fractures extending to a dural sinus or jugular bulb. CTV is comparable to MRV for the diagnosis of cerebral venous thrombosis, though MRV is more sensitive when combined with MRI. Based on the current evidence, CTV or MRV (depending on the institutional preference and availability) is considered first line in imaging patients with suspected intracranial venous injury.

Variant 9: Suspected Post-traumatic Cerebrospinal Fluid Leak

Acute closed head injury can also be associated with cerebrospinal fluid (CSF) leak. This occurs in 10% to 30% of skull base fractures and most often presents with rhinorrhea (80% of cases) in the setting of frontobasal fracture. However, it may present with otorrhea in the setting of temporal bone fracture. Most post-traumatic CSF leaks are acute in presentation and can be diagnosed clinically when CSF rhinorrhea or otorrhea is confirmed with a beta-2 transferrin or beta trace protein assay. High-resolution noncontrast CT through the skull base (facial bones for rhinorrhea and temporal bones for otorrhea) can be used to identify the source of the leak in the acute or chronic setting and has been shown to be superior to CT cisternography and radionuclide cisternography. Patients with multiple potential sites may require CT cisternography to identify the culprit site. Radionuclide cisternography using indium (In)-111 diethylenetriaminepentacetate (DTPA) may have a role in cases with evidence of a CSF leak with negative or inconclusive noncontrast skull base CT and CT cisternography. MRI with high-resolution T2-weighted sequences may have a role if a post-traumatic cephalocele is suspected.

Summary of Recommendations

- NOC, CCHR, and NEXUS-II studies are published guidelines with a high sensitivity for identifying patients with minor or mild acute closed head injury who can avoid neuroimaging.
- In patients with minor or mild acute closed head injury who require neuroimaging, noncontrast CT is the most appropriate initial imaging study.
- In moderate to severe acute closed head injury, noncontrast CT is the most appropriate initial imaging study.
- In short-term follow-up imaging of acute TBI without neurologic deterioration, noncontrast CT is the most appropriate imaging study, but only in patients with risk factors (such as subfrontal/temporal intraparenchymal contusions, anticoagulation, age >65 years, or intracranial hemorrhage with volume >10 mL).
- In short-term follow-up imaging of acute TBI with neurologic deterioration, delayed recovery, or persistent unexplained deficits, noncontrast CT is the most appropriate imaging study, but MRI has a complementary role when the patient has neurologic findings or symptoms not sufficiently explained by CT. In patients with suspected post-traumatic infection, contrast-enhanced MRI or CT may be helpful.
- In subacute to chronic TBI, noncontrast MRI is the most appropriate imaging study for detection of underlying brain injury in patients with new, persistent, or slowly progressive symptoms. In patients with rapidly evolving neurologic deficits, noncontrast CT may be the more appropriate imaging study due to its ready availability. Advanced neuroimaging techniques (SPECT, PET, perfusion CT and MRI, DTI, fMRI, and MRS) are areas of active research but are not considered routine clinical practice at this time.
- In suspected intracranial arterial injury, CTA or MRA (depending on the institutional preference and availability) is the most appropriate initial imaging study. Catheter angiography is typically reserved for problem solving or in preparation for intervention.
- In suspected intracranial venous injury, CTV or MRV (depending on the institutional preference and availability) is the most appropriate initial imaging study.
- In suspected post-traumatic CSF leak, high-resolution noncontrast skull base CT may be helpful to identify the source of the leak. CT or radionuclide cisternography may have a secondary role if skull base CT is inconclusive. High-resolution MRI may have a role if post-traumatic cephalocele is suspected.

Abbreviations

- CCHR, Canadian CT Head Rules
- CSF, cerebrospinal fluid
- CT, computed tomography
- CTA, computed tomography angiography
- CTV, computed tomography venography
- DTI, diffusion tensor imaging
- DTPA, diethylenetriaminepentacetate
- FDG-PET, fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography
- GCS, Glasgow Coma Scale
- HMPAO, hexamethylpropyleneamine oxime
- In, indium
- MRA, magnetic resonance angiography

- MRI, magnetic resonance imaging
- MRV, magnetic resonance venography
- NEXUS, National Emergency X-Ray Utilization Study
- NOC, New Orleans Criteria
- SPECT, single-photon emission tomography
- Tc, technetium

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
	<0.1 mSv	<0.03 mSv
	0.1-1 mSv	0.03-0.3 mSv
	1-10 mSv	0.3-3 mSv
	10-30 mSv	3-10 mSv
	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Head trauma

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Emergency Medicine

Internal Medicine

Neurology

Nuclear Medicine

Radiology

Intended Users

Advanced Practice Nurses

Health Plans

Hospitals

Managed Care Organizations

Physician Assistants

Physicians

Students

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of imaging procedures for patients with head trauma

Target Population

Patients with head trauma

Interventions and Practices Considered

1. Computed tomography (CT), head
    - Without contrast
    - Without and with contrast
    - With contrast
2. Computed tomography angiography (CTA), head and neck, with contrast
3. CT venography, head, with contrast
4. CT, maxillofacial, without contrast
5. CT, temporal bone, without contrast
6. CT cisternography, head, with contrast
7. Magnetic resonance imaging (MRI), head
    - Without contrast
    - Without and with contrast
    - Without contrast with diffusion tensor imaging (DTI)
8. Functional MRI (fMRI), head, without contrast
9. Magnetic resonance angiography (MRA), head and neck
    - Without and with contrast
    - Without contrast
10. Magnetic resonance venography, head
    - Without contrast
    - Without and with contrast
11. Magnetic resonance spectroscopy, head, without contrast
12. X-ray, skull
13. Cervicocerebral arteriography
14. Technetium (Tc)-99m hexamethylpropyleneamine oxime (HMPAO) single-photon emission computed tomography (SPECT), head
15. Fluorine-18-labeled fluorodeoxyglucose-positron emission tomography (FDG-PET)/CT, head
16. Indium-111 diethylenetriaminepentacetate (In-111 DTPA) cisternography

Major Outcomes Considered

- Sensitivity and specificity of neuroimaging procedures for the detection of significant findings in head-injured patients
- Positive and negative predictive values of neuroimaging procedures in the management of patients with head injuries

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Summary

Of the 64 citations in the original bibliography, 30 were retained in the final document. Articles were removed from the original bibliography if they were more than 10 years old and did not contribute to the evidence or they were no longer cited in the revised narrative text.

A new literature search was conducted in March 2014 to identify additional evidence published since the *ACR Appropriateness Criteria® Head Trauma* topic was finalized. Using the search strategy described in the literature search companion (see the "Availability of Companion Documents" field), 122 articles were found. One article was added to the bibliography. One hundred twenty-one articles were not used due to either poor study design, the articles were not relevant or generalizable to the topic, the results were unclear, misinterpreted, or biased, or the articles were already cited in the original bibliography.

The author added 32 citations from bibliographies, Web sites, or books that were not found in the new literature search.

One citation is a supporting document that was added by staff.

See also the American College of Radiology (ACR) Appropriateness Criteria® literature search process document (see the "Availability of Companion Documents" field) for further information.

Number of Source Documents

Of the 64 citations in the original bibliography, 30 were retained in the final document. The new literature search conducted in March 2014 identified 1 article that was added to the bibliography. The author added 32 citations from bibliographies, Web sites, or books that were not found in the new literature search. One citation is a supporting document that was added by staff.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Definitions of Study Quality Categories

Category 1 - The study is well-designed and accounts for common biases.

Category 2 - The study is moderately well-designed and accounts for most common biases.

Category 3 - The study has important study design limitations.

Category 4 - The study or source is not useful as primary evidence. The article may not be a clinical study, the study design is invalid, or conclusions are based on expert consensus.

The study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);

Or

The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;

Or

The study is an expert opinion or consensus document.

Category M - Meta-analysis studies are not rated for study quality using the study element method because the method is designed to evaluate individual studies only. An "M" for the study quality will indicate that the study quality has not been evaluated for the meta-analysis study.

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author assesses the literature then drafts or revises the narrative summarizing the evidence found in the literature. American College of Radiology (ACR) staff drafts an evidence table based on the analysis of the selected literature. These tables rate the study quality for each article included in the narrative.

The expert panel reviews the narrative, evidence table and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the variant table(s). Each individual panel member assigns a rating based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development documents (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

<u>Rating Appropriateness</u>

The American College of Radiology (ACR) Appropriateness Criteria (AC) methodology is based on the RAND/UCLA Appropriateness Method. The appropriateness ratings for each of the procedures or treatments included in the AC topics are determined using a modified Delphi method. An initial survey is conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. The expert panel members review the evidence presented and assess the risks or harms of doing the procedure balanced with the benefits of performing the procedure. The direct or indirect costs of a procedure are not considered as a risk or harm when determining appropriateness (additional assumptions regarding rating appropriateness can be found in the document Rating Round Information). When the evidence for a specific topic and variant is uncertain or incomplete, expert opinion may supplement the available evidence or may be the sole source for assessing the appropriateness.

The appropriateness is represented on an ordinal scale that uses integers from 1 to 9 grouped into three categories: 1, 2, or 3 are in the category "usually not appropriate" where the harms of doing the procedure outweigh the benefits; and 7, 8, or 9 are in the category "usually appropriate" where the benefits of doing a procedure outweigh the harms or risks. The middle category, designated "may be appropriate," is represented by 4, 5, or 6 on the scale. The middle category is when the risks and benefits are equivocal or unclear, the dispersion of the individual ratings from the group median rating is too large (i.e., disagreement), the evidence is contradictory or unclear, or there are special circumstances or subpopulations which could influence the risks or benefits that are embedded in the variant.

The ratings assigned by each panel member are presented in a table displaying the frequency distribution of the ratings without identifying which members provided any particular rating. To determine the panel's recommendation, the rating category that contains the median group rating without disagreement is selected. This may be determined after either the first or second rating round. If there is disagreement after the first rating round, a conference call is scheduled to discuss the evidence and, if needed, clarify the variant or procedure description. If there is still disagreement after the second rating round, the recommendation is "may be appropriate."

This modified Delphi method enables each panelist to articulate his or her individual interpretations of the evidence or expert opinion without excessive influence from fellow panelists in a simple, standardized, and economical process. For additional information on the ratings process see the Rating Round Information document.

Additional methodology documents, including a more detailed explanation of the complete topic development process and all ACR AC topics can be found on the ACR Web site (see also the "Availability of Companion Documents" field).

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

The guideline developers reviewed a published cost analysis.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria (AC).

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current medical evidence literature and the application of the RAND/UCLA appropriateness method and expert panel consensus.

<u>Summary of Evidence</u>

Of the 64 references cited in the *ACR Appropriateness Criteria® Head Trauma* document, 62 are categorized as diagnostic references including 1 well designed study, 12 good quality studies, and 21 quality studies that may have design limitations. Additionally, 1 reference is categorized as a therapeutic reference. There are 29 references that may not be useful as primary evidence. There is 1 reference that is a meta-analysis study.

While there are references that report on studies with design limitations, 13 well designed or good quality studies provide good evidence.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Neuroimaging plays a critical role in the management of head trauma, from identifying patients with traumatic brain injury (TBI) and determining which of those injuries require immediate treatment to assisting in patient prognosis.

Potential Harms

Relative Radiation Level

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The (RRLs) are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Qualifying Statements

Qualifying Statements

- The American College of Radiology (ACR) Committee on Appropriateness Criteria (AC) and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U. S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.
- ACR seeks and encourages collaboration with other organizations on the development of the ACR AC through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply individual or society endorsement of the final document.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Living with Illness

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Shetty VS, Reis MN, Aulino JM, Berger KL, Broder J, Choudhri AF, Karagulle Kendi AT, Kessler MM, Kirsch CF, Luttrull MD, Mechtler LL, Prall JA, Raksin PB, Roth CJ, Sharma A, West OC, Wintermark M, Cornelius RS, Bykowski J, Expert Panel on Neurologic Imaging. ACR Appropriateness CriteriaÂ® head trauma. Reston (VA): American College of Radiology (ACR); 2015. 18 p. [64 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2015

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Neurologic Imaging

Composition of Group That Authored the Guideline

Panel Members: Vilaas S. Shetty, MD (*Principal Author*); Martin N. Reis, MD (*Research Author*); Joseph M. Aulino, MD; Kevin L. Berger, MD; Joshua Broder, MD; Asim F. Choudhri, MD; Ayse Tuba Karagulle Kendi, MD; Marcus M. Kessler, MD; Claudia F. Kirsch, MD; Michael D. Luttrull, MD; Laszlo L. Mechtler, MD; J. Adair Prall, MD; Patricia B. Raksin, MD; Christopher J. Roth, MD; Aseem Sharma, MD; O. Clark West, MD; Max Wintermark, MD; Rebecca S. Cornelius, MD (*Specialty Chair*); Julie Bykowski, MD (*Panel Chair*)

Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Davis PC, Wippold FJ II, Cornelius RS, Aiken AH, Angtuaco EJ, Berger KL, Broderick DF, Brown DC, Douglas AC, McConnell CT Jr, Mechtler LL, Prall JA, Raksin PB, Roth CJ, Seidenwurm DJ, Smirniotopoulos JG, Waxman AD, Coley BD, Expert Panel on Neurologic Imaging. ACR Appropriateness Criteria® head trauma. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 14 p. [64 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Available from the American College of Radiology (ACR) Web site.

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2015 Oct. 3 p. Available from the American College of Radiology (ACR) Web site.
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 2015 Feb. 1 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Evidence table development. Reston (VA): American College of Radiology; 2015 Nov. 5 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Topic development process. Reston (VA): American College of Radiology; 2015 Nov. 2 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Rating round information. Reston (VA): American College of Radiology; 2015 Apr. 5 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2015 Sep. 3 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 2015. 129 p. Available from the ACR Web site.
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 2015 Jul. 2 p. Available from the ACR Web site.
- ACR Appropriateness Criteria® head trauma. Evidence table. Reston (VA): American College of Radiology; 2015. 26 p. Available from the ACR Web site.
- ACR Appropriateness Criteria® head trauma. Literature search. Reston (VA): American College of Radiology; 2015. 1 p. Available from the ACR Web site.

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI on July 31, 2001. The information was verified by the guideline developer as of August 24, 2001. This summary was updated by ECRI on August 11, 2006. This summary was updated by ECRI Institute on July 1, 2009. This summary was updated by ECRI Institute on January 13, 2011 following the U.S. Food and Drug Administration (FDA) advisory on gadolinium-based contrast agents. This summary was updated by ECRI Institute on August 31, 2012. This summary was updated by ECRI Institute on January 22, 2016.

Copyright Statement

Instructions for downloading, use, and reproduction of the American College of Radiology (ACR) Appropriateness Criteria® may be found on the ACR Web site.

Disclaimer

NGC Disclaimer

The National Guideline Clearinghouseâ„¢ (NGC) does not develop, produce, approve, or endorse the guidelines represented on this site.

All guidelines summarized by NGC and hosted on our site are produced under the auspices of medical specialty societies, relevant professional associations, public or private organizations, other government agencies, health care organizations or plans, and similar entities.

Guidelines represented on the NGC Web site are submitted by guideline developers, and are screened solely to determine that they meet the NGC Inclusion Criteria which may be found at http://www.guideline.gov/about/inclusion-criteria.aspx.

NGC, AHRQ, and its contractor ECRI Institute make no warranties concerning the content or clinical efficacy or effectiveness of the clinical practice guidelines and related materials represented on this site. Moreover, the views and opinions of developers or authors of guidelines represented on this site do not necessarily state or reflect those of NGC, AHRQ, or its contractor ECRI Institute, and inclusion or hosting of guidelines in NGC may not be used for advertising or commercial endorsement purposes.

Readers with questions regarding guideline content are directed to contact the guideline developer.